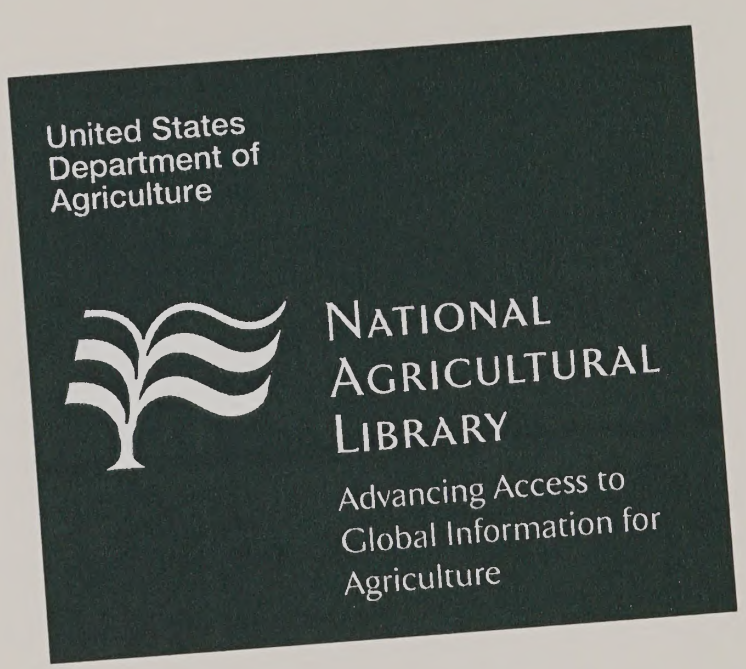
A National Program of Research for

RICE

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES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FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

February 1969

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INTRODUCTION

Rice Research Needs Through 1977

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ASSIGNMENT AND BACKGROUND:

A long-range study of Agricultural and forestry research was undertaken at the request of the Senate Subcommittee on Agricultural Appropriations. It was initiated through the cooperative efforts of the Secretary of Agriculture and the Chairman of the Executive Committee of the Association of State Universities and Land-Grant Colleges (ASULGC). Representatives assigned by USDA and the Experiment Station Committee on Organization and Policy (ESCOP) conducted the study and prepared their report entitled "A National Program of Research for Agriculture." The report aggregates agricultural and forestry research into 91 broad problem areas and recommends for each the level of program to be attained in 1972 and 1977, 5 and 10 years after the completion of the study. The Secretary of Agriculture and the Chairman of the Executive Committee, ASULGC, jointly submitted it to the Senate Committee on Appropriations on October 13, 1966.

The report proposed further analysis of each of the 91 problem areas. At its July 1966 meeting, the Agricultural Research Planning Committee (ARPC) took steps to partially implement this proposal by recommending that the Department and State Agricultural Experiment Stations establish several task forces for study of significant segments of agricultural research.

Within the general framework of the long-range study, the task force was charged with indicating areas of research which need emphasis and with determining the most efficient procedures for organizing and carrying out the specific research involved. Taking present arrangements into account, the Task Force will recommend a reasonable division of responsibilities and effort, e.g., SMYs, and suitable organization for conducting the program. The Research Problem Areas included in the assignment of the Rice Task Force were 207, 208, 209, 307, 308, 309, 405, 406, 408, 501 and 504. A tabulation of SMYs is given in Table 1.

SITUATION: Rice was grown on about 2,360,000 acres in 1968. Rice is a major crop in the States of Arkansas, California, Louisiana, and Texas. Rice also is an important crop in the "Delta" area in the State of Mississippi and small acreages are grown in Missouri, and several other states. Rice is produced on many types of soil and under a wide range of climatic, and other environmental conditions and it is subject to damage by many insect, disease and weed pests. Also many farm management practices and cropping systems are followed by rice farmers in this country and consumers demand rices with different cooking and processing characteristics.

Insects, diseases and weeds are serious pests of growing rice. The control of these pests will require a concerted effort in order to develop control measures, including resistant varieties. Rice in the United States is grown under flood irrigation so cultural problems such as fertilization, weed control and crop rotation are quite different than for upland cereal crops. This will require specific research with rice to solve these problems. Rice is grown under many ecological conditions. Experiments must be conducted under each ecological condition to determine the best cultural practices and methods to control insects, diseases, weeds and other pests. Rice production in the United States is fully mechanized. Since rice is flood-irrigated, field operations usually are conducted under conditions that require heavy-duty implements which must be improved or developed by research. Research also is needed to determine the best farm management practices for rice farming operations. Rice varieties must be evaluated to find the types that are productive, nonlodging, and have other desirable plant characteristics; that are resistant to insects and diseases; and that have the desired cooking and processing characteristics. The genetics of these characteristics must then be determined and the desirable characteristics combined in new improved varieties. Research also is needed to determine the amount of heterosis in rice. If results from these experiments are positive, research should be initiated to develop hybrid rice. Rice in the United States is harvested with a moisture content above the safe storage level and most of the rice is stored where the air temperature and relative humidity are quite high. This increases the hazard of storing rice. Research is needed on drying and storing of both rough and milled rice to develop storage methods that will prevent losses by fungi and insects. The need for improved nutritional value of rice and the development of new uses and new products should be fully explored and appropriate lines of research developed. A system of grades and standards recognizing meaningful factors should be developed. Improved handling techniques and equipment also are needed to reduce losses in processing and cost of labor. Information also is needed to help the rice industry develop effective marketing strategies and promotional activities, and increase foreign markets. There also is a need to develop the best uses for rice by-products and methods for disposal of crop residues.

The character and magnitude of the potential benefits of the research programs were based on the 1968 production of 108 million 100-pound bags on

2.36 million acres. The value of the 1968 crop was $496.8 million, based on an average support price of $4.60 per 100 pounds.

PRESENT EFFORT: In 1966 it was estimated that 38 scientific man-years of effort were expended on rice research in the United States. This was equally divided between USDA and SAES. An undetermined amount of private effort was expended. The public agency work was done principally at two locations in each of the major producing States, at one location in a minor producing State and at two or three Federal laboratories. Federal and State effort is about equal in protection research. In production efficiency research, Federal agencies have conducted research primarily in breeding and State agencies have devoted more of their attention to other phases of rice production research. Most of the research on consumer acceptance, new products and marketing efficiency has been by Federal agencies.

FUTURE EFFORT: It is believed that future rice research should follow the same general philosophy as the present research. That is, both State and Federal agencies should engage in basic and applied research and share the information fully and promptly with farmers, industry and consumers. The allocation of Federal and State personnel to rice research problems must of necessity be based upon the availability of funds and personnel. Insofar as possible, research should be planned to give results with wide adaptation. There are certain types of pest control and production problems that are rather narrow, however, much of the basic research in these two areas will have wide application. Results of research in the areas of consumer acceptance, new product development, quality control and marketing efficiency will have wide application.

In addition to its basic assignment, the Rice Task Force recognizes the need for the consideration of rice and rice products in other Research Problem Areas. These additional RPAs are 316, 407, 506 and 601.

Research under RPA 316, "Farm adjustment and management," is an important part of the present rice research program. The Rice Task Force feels that this research should continue at least at the present level.

Research under RPA 407, "New and improved feed, textiles and industrial products from field crops," is needed to develop methods for maximum use of rice byproducts. Research in this area has been sporadic in the past. Continuing research programs are needed to develop nutritious and palatable feeds and economic industrial products from rice byproducts. New methods to upgrade hulls for use in animal feeds would augment the sizable quantities now being disposed of in feed mixtures. Research in this area also would help alleviate the perennial problem of hull disposal. Air and land pollution regulations will soon preclude all open burning and uncontrolled indoor burning. Alternate disposal methods are therefore urgently needed for the nearly 500,000 tons of hulls now burned or dumped.

Research under RPA 506, "Supply, demand and price analysis," is now underway. This research should be continued at the present level.

There is a need for considering rice as one of the commodities studied under RPA 601, "Expansion of foreign markets - - - - ." Some effort is being expended in this area now. The Rice Task Force recommends a modest increase in manpower in this area.

The suggested allocation of manpower to the four additional Research Problem Areas is shown in Table 2.

Table 1: Summary of SMY Inventory and Recommendations - Rice

No.	Research Problem Area	1966 1/ Inventory	Task Force Recommendations 1972	1977
207	Insect control	4	6	8
208	Disease control	5	9	13
209	Weed control	3	5	6
	Subtotal-Protection	12	20	27
307	Biological efficiency	12	17	21
308	Mechanization	1	2	3
309	Systems analysis	- 2/	1	2
405	Consumer acceptibility	1	2	3
	Subtotal-Production	14	22	29
406	Food products	5	6	9
408	Market quality	5	8	9
501	Grades and standards	-	1	2
504	Marketing efficiency	2	5	6
	Subtotal-Marketing	7	14	17
	Grand Total	38	62	86

1/ 1966 base from Volume 1, Table 1, "An Inventory of Agricultural Research."
2/ Indicates less than 1/2 SMYs.

Table 2: Summary of SMY Inventory and Task Force Recommendations for Other RPAs

	Research Program Area	1968 Inventory	Recommendations 1972	Recommendations 1977
316	Farm adj. and management	2	2	2
407	Feed and non-food	0	2	3
506	Supply, demand and price	1	1	1
601	Foreign markets	0	2	4
	Total	3	7	10

Projected Research Program for Rice

PRINCIPAL RESEARCH PROBLEM AREAS: Research on rice is conducted in the eleven Research Problem Areas listed in Table 1. Recommendations of the Joint Rice Task Force on the level of research required are given below.

TITLE: Control of Insects by Developing Resistant Varieties of Rice and Changing Cultural Practices. RPA 207-A

SITUATION: Insecticides are the first line of defense against insects. The use of insecticides may lead to undesirable residues on the plant. Some insecticides are also harmful to wildlife and upset the balance of beneficial organisms in the ricefield. Some insects have become resistant to insecticides. The development of an insect resistant variety of rice provides an effective economical and safe way to deal with insect pests attacking rice. Very little research has been done up to the present time on the development of rice varieties with resistance to insects. The development of insect resistant varieties is a long-term research program requiring a minimum of 10 years. Research should be initiated immediately to find insect resistant germ plasm that can be introduced in a breeding program to develop resistant varieties. A germ plasm bank should be established to include all possible sources of resistance to insects. This bank could possibly be located at the National Seed Storage Laboratory, Fort Collins, Colorado. Any breeding program to develop resistant varieties should be a continuous one because strains of insects often develop that can attack varieties that were previously resistant.

Frequently a slight modification in the growing of a crop such as rice may prevent or lessen insect damage. These cultural practices may include changes in time of planting, methods of planting, tillage practices, crop rotation, fertilizer application, etc. Special emphasis should be placed on studies dealing with water management practices in relation to insect infestations. Cultural practices alone may not give completely satisfactory insect control. Nevertheless they are often of some importance in minimizing injury.

OBJECTIVE: To seek, find, and identify sources of insect resistant germ plasm in rice to the various insect species and to determine the nature of resistance and the mode of inheritance and to establish a germ plasm bank of resistant genotypes. With the assitance of the plant breeders, to transfer resistant germ plasm to high yielding, well adapted rice varieties. To determine the effect of management practices and cultural practices on insect populations, and to identify changes in insect incidence associated with these new practices.

RESEARCH APPROACH:

A. Collect rice varieties from all the rice-growing areas of the world and to evaluate these varieties for insect resistant germ

plasm. Establish a germ plasm bank of resistant genotypes.

B. Transfer the resistant germ plasm to well adapted varieties using established genetic techniques and breeding practices.

C. Study the genetics and manner of inheritance of rice insect resistance, using various cytogenetic and genetic techniques.

D. Develop varieties that are resistant to more than one insect.

E. Determine the presence and abundance of physiological races, if and when they occur, and take immediate steps to find germ plasm resistant to these new physiological races.

F. Conduct basic chemical, physiological, and genetic studies to determine the nature of resistance.

G. Determine the effect of growing resistant varieties over large areas of insect parasite populations.

H. Study the effect of various crop rotation, tillage, and water management practices on the insect population.

I. Indentify changes in insect and parasite populations and their relation to new management practices.

J. Coordinate with research under 208-A, 209-A, 307-A, B-2, C-1, C-3, -D, 308-A, 405, and 408-C.

POTENTIAL BENEFITS: Controlling insects by the growing of resistant varieties and changing of cultural practices would reduce the need and cost of insecticide control measures thereby reducing hazards to the health of man and wildlife and lowering the cost of control. Food, soil, and water pollution would also be reduced. Rice yields would be increased by reducing insect damage.

RECOMMENDED RESEARCH EFFORT: T F RECOMMENDATION

1972	1977
2	2

TITLE: Biological Control. RPA 207-B

SITUATION: Parasites and other biological control agents play a major role in reducing rice insect populations. Parasites are believed to be key mortality factors in keeping stem borer populations and damage below the threshold of economic damage. In recent years, a great deal of research has been devoted to the development of techniques for the mass production

and release of parasites to reduce insect populations. Tests should be initiated as soon as possible to test this technique against insects attacking rice in the United States. Under some conditions naturally occurring diseases may terminate what appears to be an extensive insect outbreak. There is need for research to determine if such pathogens can be propagated in the laboratory and utilized for the control of insects.

OBJECTIVE: To make maximum use of parasites, predators, and insect pathogens to control insects attacking rice.

RESEARCH APPROACH:

A. Search for predators, parasites, and pathogens of insects attacking rice in their native habitats. Propagate and mass produce these agents so that they can be disseminated over the rice-growing area of the United States.

B. Evaluate the effectiveness of both native and introduced parasites and diseases for control of major insects attacking rice in the United States.

C. Develop techniques for mass production and release of parasites, predators, and insect pathogens, and evaluate these organisms for field control.

D. Coordinate with research under 208-E, 208-F, and 209-E.

POTENTIAL BENEFITS: Reduce cost of production and increase yield and quality, reduce the need for chemicals thus reducing hazards to beneficial insects and wildlife, and reduce air, food, soil, and water pollution, and/or contamination.

RECOMMENDED RESEARCH EFFORT: T F RECOMMENDATIONS

1972	1977
1	2

TITLE: Biology of Rice Insects and New Approach to Insect Control. RPA 207-C

SITUATION: Basic information on biology, behavior, development, host range, and population dynamics is needed on all insects attacking rice to develop adequate control methods. Weak links in insect life cycle development must be found and exploited through biological studies to develop new and/or more effective control measures. Before any meaningful research studies can be conducted to develop effective control measures, insect pests, parasites, and predators, and insect vectors of plant diseases attacking rice must be systematically identified and classified. There is a need for the identification and classification of physiological races of parasites

that have apparently developed in rice fields. Insects are attracted to various stimili including specific substances and host plants, sex attractants, light, sound, and other electromagnetic radiation. The use of chemosterilants or insecticides in conjunction with attractants has good possibilities of controlling insects attacking rice. The possibility of using natural or synthetic hormones to control rice insects should be investigated. There has been little or no research conducted on the use of insects for their own destruction by employing the sterility or other genetic principles on insects of rice. It has been demonstrated that when sterile insects are released and are able to compete with the normal insect population for reproduction, the biotic potential of the natural population can be greatly reduced.

OBJECTIVE: Determine the life history, distribution, occurrence, abundance, habits, nutritional requirements, and other biological, physiological, and ecological characteristics of insects attacking rice on the development of various types of control for insects attacking rice. Investigate methods of sterilizing insects, isolating attractants, hormones, and other biological active materials and use this information to develop methods of controlling or suppressing insect populations.

RESEARCH APPROACH:

A. Determine the nutritional requirements of rice insects using standard laboratory procedures, and develop artificial diets for the mass rearing of the insects.

B. Conduct laboratory, cage, and field studies on rice insects using accepted biological procedures and techniques to obtain basic information on population dynamics, mating behavior, migration habits, and other biological activities which can be used to conduct suppression, eradication, or control studies and to develop life tables for different ecological areas.

C. Determine the physiological processes of insect development, using accepted laboratory procedures. Locate, isolate, and identify hormones that can be used to interfere with insect growth and development.

D. Collect, preserve, and conduct taxonomic studies on all insects attacking rice, and all parasites, and predators associated with insect pests of rice, in order to identify and classify them using standard taxonomic keys. Develop tests for classifying physiological races.

E. Determine the effect that various insect populations at different times, under different growing conditions have on yield and quality of rice, and determine the economic injury threshold for each insect species.

F. Investigate the possibility of sterilizing rice insects with radiation or chemosterilants, using established bioradiation techniques and determine if the sterile male release technique can be used for areawide control.

G. Isolate sex attractants from insects attacking rice. Conduct laboratory and field studies on the feasibility of controlling insects by the use of attractants.

H. Evaluate light, sound, and other electromagnetic radiation as possible insect attractants.

I. Coordinate with research under 207-B and 307-D.

POTENTIAL BENEFITS: Reduce the cost of production by eliminating the need for insecticides. Reduce residue hazards and reduce air, food, soil, and water pollution. Increase yield by reducing insect damage.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	2

TITLE: Chemical Control. RPA 207-D

SITUATION: Insecticides are the first line of defense against rice insects. They have been very effective in controlling insect pests of rice. However, insects do become resistant to insecticides that formerly gave satisfactory control. A need for new insecticides to control rice insect infestations will exist for the forseeable future. Some insecticides are not compatible with herbicides used on rice. Some insecticides reduce populations of beneficial insects and wildlife. Research is needed to find materials with maximum biological activity against the target insect with minimum activity against man, animals, and other useful organisms in the environment. Selective biodegradable insecticides are needed that do not accumulate in plant and animal tissues and that are not magnified through food chains. Since residue problems may arise from insecticide drift to nontarget areas, there is a need for improved formulations and insecticide application equipment.

OBJECTIVE: To develop cheaper and more effective chemical control methods that will leave no objectionable residues in rice, soil, and water, cause a minimum of air pollution, cause minimum reduction in populations of beneficial insects, predators, and parasites, and are nonhazardous to man and animals.

RESEARCH APPROACH:

A. Evaluate new insecticides in the laboratory and field, using accepted procedures and techniques for insect control. Conduct studies to determine if they are compatible with herbicides being used on rice.

B. Test various insecticide formulations, rates, and time of application against different rice insect species, using both ground and aerial equipment.

C. Determine effect of insecticides on beneficial insects, wildlife, domesticated animals, and man.

D. Determine insecticide residues in the plant, soil, and seed after application to the rice. Develop methods of reducing residues.

E. Coordinate with research under 209-A, -C, -E, and 307 B-2.

POTENTIAL BENEFITS: Safer more effective insecticides would reduce residue hazards to health of man and animals and would lower cost of control. Rice yields would be increased by reducing insect damage.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
2	2

TITLE: Control of Diseases Through Genetics and Breeding. RPA 208-A

SITUATION: Rice diseases reduce yield, lower quality and restrict managerial options of growers, seed-producers, millers, and processors. The magnitude of these losses is imprecisely determined but is considerable each year and quite substantial in others. Methods for identifying resistance in varieties and breeding lines to the races of the rice blast pathogen, the stem rot pathogen and physiological straighthead are developed. The mode of inheritance of resistance has been determined for some races of the rice blast organism. Varieties have been released with resistance to these widespread recurring diseases but in no variety is there combined resistance to these three diseases nor is there suitable resistance to any one of these diseases in all grain types.

OBJECTIVE: To identify genes and/or cytoplasmic factors for resistance to rice blast, stem rot, and straighthead; determine their modes of inheritance and incorporate high levels of resistance into short, medium and long grain varieties having superior agronomic and quality characteristics.

RESEARCH APPROACHES:

A. Monitor the spectrum of blast races annually throughout the rice growing region and select most prevalent ones for challenging advanced nursery materials.

B. Search for sources of resistance to each disease among entries in the world rice collection, related species and all breeding lines and varieties.

C. Employ mutagenic agents, chromosome doubling and other cytological techniques to break undesirable linkages and to recover resistant genes from inferior genomes.

D. Determine the mode of inheritance of resistance to each disease.

E. Incorporate resistance by systematic crossing and testing into superior agronomic varieties or each grain type and quality class.

F. Coordinated with 307-A, 405, 406.

POTENTIAL BENEFITS: Increases in yield, improvement of processing quality and greater latitude in selection of varieties for specific production regimes or product market requirements. The magnitude of benefits from this research is estimated to be equivalent to 3% of the total value of the crop.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
2	2

TITLE: Biology and Control of Rice Kernel Smut Disease. RPA 208-B

SITUATION: The rice kernel smut disease has increased in prevalence and severity with the increased use of nitrogen fertilizer. Yield loss estimates range from 1-3% annually with losses as high as 25% occurring in individual fields. Likewise substantial losses are incurred in milling and parboiling. Partially smutted kernels remaining in milled rice seriously detract from its appearance and in the parboiling process they impart a grey color to the entire batch. Several high yielding potential varieties have not been released largely because of their susceptibility to kernel smut. Life history studies on the causal fungus, Tilletia barclayana reveal that it infects individual rice florets shortly before or during panicle emergence and pollination. The parameters of each environmental element, host physiology and inoculum concentration necessary for infection and symptom expression have not been elucidated. Therefore, rather than reaction testing under controlled conditions, searches for sources of resistance and screening of breeding material to develop resistant varieties have been limited to small outlying nurseries in "smut suspect" locations in Arkansas.

OBJECTIVE: To determine the optimum environment, host physiological condition and inoculum levels for smut infection and development under controlled conditions.

RESEARCH APPROACHES:

A. Determine the diurnal temperature, humidity, light and nutrient program for optimal growth of rice in environmental chambers, during the periods of panicle initiation, emergence and pollination.

B. Inoculate developing, emerging and pollinating panicles with primary and secondary sporidia in various liquid and dust vehicles.

C. Measure disease development under a wide range of environmental conditions and determine optimum conditions for infection and symptom expression.

D. Determine the relationship between host metabolism, primarily nitrogen metabolism, and host reaction to penetration.

E. Select plants with metabolic systems that are unable to support growth of the pathogen or are inhibitive to it.

F. Coordinate with 307-A, 405, 406.

POTENTIAL BENEFITS: These studies will permit systematic searches for resistance and thereby development of resistant varieties, either by inoculation test or simple laboratory test for chemical constituents in

varieties and breeding lines. Also information on environmental requirements for disease development will help select cultural practices inimical to disease development. Potential yield and quality increases benefits have been estimated to be about 1.5% of the current crop.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	1	1

TITLE: The Role of Fungi in Kernel Discoloration and Sterility. RPA 208-C

SITUATION: The long-standing problem of discolored and pecky kernels in milled rice has been accentuated with the development of parboiling and the concomitant increase in use of rice in precooked foods and convenience foods such as packaged dinners. Blackened kernels are intolerable in these products and must be removed photoelectrically. As in the case of smut, discoloration of the entire parboil batch by these fungi is a significant problem. Parboiling strengthens these damaged kernels, consequently they are more likely to remain intact in the milled rice rather than being broken and removed as they are in the standard milling procedures. Furthermore, the rice import regulations of certain Asian countries that requires the complete absence of Penicillium islandicum and P. toxicarum, two mycotoxin producing fungi, and the general increased public concern over mycotoxins as carcinogens, has refocused attention on this group of organisms in the microflora of the rice kernels. Many of these same fungi are associated with sterile florets in the field and in many years these occur in sufficient amounts to reduce yields appreciably. Helminthosporium oryzae, the organism of brown spot of rice, is most widespread and frequently encountered but there are many fungi which occur and predominate depending upon variety, locality and cultural practices such as double cropping and degree of weed and insect control.

OBJECTIVE: To survey and identify the fungi associated with sterile florets and discolored rice kernels and elucidate their etiology to the extent necessary for formulating control measures.

RESEARCH APPROACHES:

A. Establish a sampling network of Arkansas, Texas and Louisiana rice graders, elevator operators and millers to obtain annually, representative rice samples of each variety from several localities and cultural systems.

B. Isolate and identify the fungi from rice grown in various regions and varieties.

C. Determine their means of dissemination, penetration, growth and overwintering requirements.

D. Examine anthesis of existing varieties under controlled environmental conditions with time lapse photography for factors governing opening and closing of florets and the effects of individual fungi on the pollination and kernel maturation process.

E. Search for antibiotics in rice florets or morphological and physiological characters that could be used in selections of varieties able to escape or resist penetration by the fungi and damage from insects to the developing grains.

F. Coordinate with 307, 405, 406.

POTENTIAL BENEFITS: Correlation of fungal flora with varieties, localities and cultural practices would give insight into means of avoiding damage and studies on mode of entry and development would aid in selecting resistant varieties. Yield increases would be about one percent of the current crop and savings in quality about three percent for a total of four percent.

RESEARCH EFFORT:

T F RECOMMENDATIONS	
1972	1977
1	2

TITLE: Etiology of Leaf and Sheath Diseases and Other Endemic or Introduced Diseases Including Virus Diseases. RPA 208-D

SITUATION: Leaf smut (*Entyloma oryzae*), brown bordered leaf and sheath spot (*Rhizoctonia oryzae*) and narrow brown leaf spot (*Cercospora oryzae*) are widely distributed in the southern rice area, occurring annually in most commercial fields as plants approach maturity. Their influence on yield is usually minimal with current varieties and cultural practices but they effect quality by disrupting the normal maturation of grains. Yield reductions are, however, sometimes substantial as changes in varieties and cultural practices occur. For example, the three new long-grain varieties, Bluebelle, Dawn, and Starbonnet and the older variety Bluebonnet 50 suffered appreciable yield and quality losses in 1968 over the entire southern rice area as a result of early infection and buildup of brown bordered leaf and

sheath spot. The life histories of these three organisms have been elucidated but the disease cycles are not known nor are techniques for testing varietal reactions adequately developed for any of them. Other endemic or introduced diseases and nematodes become economically important from time to time.

OBJECTIVES: To develop varietal testing procedures for leaf smut, brown bordered leaf and sheat spot, narrow brown leaf spot and other endemic or introduced diseases or nematodes.

RESEARCH APPROACHES:

A. Survey annually for potential nematode, viral bacterial or fungal pathogens and assess their potential importance.

B. Determine the optimum laboratory or greenhouse cultural procedures for each significant or potentially significant pathogen.

C. Develop inoculation procedures under controlled condition.

D. Establish a disease rating system with enough varieties to obtain a full spectrum of resistance and susceptibility.

E. Determine the degree and extent of variation on pathogenicity in natural population of the organism.

F. Determine the hose range of the pathogens with emphasis on weeds and crop preceding rice in the rotation.

G. Coordinate with 307-A, 405, 406.

POTENTIAL BENETITS: Quality improvement and increased efficiency of breeding programs, thereby reducing some of the hazards encountered by seed producers, growers, and millers of new varieties. The magnitude of benefits from this research is estimated to be equivalent to 1% of the total value of the crop.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	2

TITLE: Control of Seedling Diseases and Seed Rot. RPA 208-E

SITUATION: Establishing a stand of uniform, vigorous healthy seedlings has always been a critical step in the production of rice. It has increased in importance since many management decisions such as timing of herbicidal or topdress nitrogen applications are based on the morphological stage of

development of the plants. Thus, as well as serving as a source of inoculum for Helminthosporium and Fusarium outbreaks later in the season, disease weakened, irregular stands may lead to herbicide damage or excessive foliage, height and lodging from improper timing of nitrogen applications. The importance of the seedling diseases is accentuated by the increase in very early seeding of rice especially for double cropping, and the practice of seeding in water for "minimum tillage" production of rice. The water mold Achlya oryzae is especially serious in the latter. There are a number of seed treatment materials reasonable effective against seedborne and soilborne organisms but better materials are needed. No suitable seed treatments for water seed rice are available.

OBJECTIVE: To locate more effective seed treatment chemicals for control of seedborne, soilborne and waterborne diseases of rice.

RESEARCH APPROACHES:

A. Screen existing fungicides for efficacy in controlling seedling blight in soil and water seeding situations.

B. Test experimental fungicides provided by chemical companies especially the new systemic fungicides and the latex stickers.

C. Examine the new hormone seed treatment Dormin and others for their effectiveness in increasing seedling vigor of rice.

D. Determine the antibiotic potential of rice hulls and their effects on germination.

E. Coordinate with 207, 209.

POTENTIAL BENEFITS: There will be some saving of seed cost but the major benefits will be more uniform stands to permit increased precision of herbicidal application nitrogen topdress application, flooding, and draining. Reduced incidence of Helminthosporium and Fusarium panicle infections later in the season would improve quality. The magnitude of benefits from this research is estimated to be equivalent to 1% of the total value of the crop.

RESEARCH EFFORT:

T F RECOMMENDATIONS	
1972	1977
1	2

TITLE: Etiology and Epidemiology of Rice Weed Pathogens. RPA 208-F

SITUATION: The control of barnyardgrass with propanil has been dramatically successful from an agronomic standpoint. There is the question of residue buildup in soil that might affect subsequent crop plants, or fish. Likewise, propanil caused damage when it drifts onto sensitive neighboring crops such as soybeans or cotton. Propanil insensitive species of grass and aquatic weeds such as Sprangletop (Leptochloa fasicularis), Christmas tree grass (Leptochloa panicoides), duck salad (Heteranthera sp.) and other weeds have not been adequately controlled with propanil or 2,4-D and are increasing in importance under the present rice culture regimes. The prospects are good that new chemical weed killers can be found to effectively control these weeds but the problems of residues and selectivity would likely persist with them also. Biological control of these weeds with endemic or introduced bacterial or fungal diseases is an attractive alternative. Plant disease pathogens are a part of our normal environment and can be highly selective for specific host. None are infectious to man or animals. Many produce motile spores that would be ideally suited for control of aquatic weeds, and many can be produced commercially with existing fermentation facilities.

OBJECTIVE: Identification and selection of organism for potential control of weeds.

RESEARCH APPROACHES:

A. Survey diseases of weeds locally and in their native environment for virulent pathogens.

B. Select one or two facultative parasites or facultative saprophytes that affect weed seedlings.

C. Determine the condition for mass production of inoculum.

D. Examine environmental factors necessary for disease development including the applications of nonselective, biodegradable resistance modifying chemicals.

E. Search for biodegradable toxins in culture filtrates that might be substituted for the intact organisms.

F. Coordinate with 209-E.

POTENTIAL BENEFITS: Economical control of weeds without hazard to man, domestic animals or fish. Avoidance of residue buildup in soils or other contamination of the environment. Benefits included in RPA 209-E.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	1	2

TITLE: Chemical or Metabolic Basis for Disease Resistance. RPA 208-G

SITUATION: The fate of a rice plant as it interacts with disease organisms in its environment is grcssly affected by its physiological condition or biochemical status during the time of this interaction. Cold water rice, for example is often severely infected with brown spot (Helminthosporium oryzae), and is more severely damaged by the rice blast organism during the seedling stage and on "dry-ground" rice. Several rice diseases are more severe in the seedling stage and as plants approach maturity, while in the interim stages of development plants are considerably more resistant. Certain rice diseases are diminished by fertilization while others are augmented. Certain herbicide treatments that alter the metabolism of rice, affect its reaction to disease. Attempts to attribute these differences in susceptibility to micro or macro morphological characters of the rice plant have been futile. No intensive studies of specific metabolic system and their relationship to disease development have been made with the prevalent endemic rice diseases.

OBJECTIVE: To relate biochemical mechanisms in rice plants to their reaction to specific pathogens.

RESEARCH APPROACHES:

A. Make comparative studies of specific metabolic systems in resistant and susceptible plants that are healthy or that have been challenged with specific pathogens.

B. Search for key biochemical intermediates in metabolic cycles that correlate with disease reaction.

C. Determine the nutrient requirements of specific pathogens and their relative abundance in plants exhibiting a spectrum of disease susceptibility.

D. Examine plants and pathogens for inhibitors or toxins that give either an advantage toward resisting invasion or stimulating susceptibility.

E. Screen herbicides and related compounds for their efficacy in modifying resistance.

F. Screen breeding lines and varieties for compounds or metabolic systems inimical to disease.

G. Coordinate with 307-A, 208-A, 208-B, and 208-H.

POTENTIAL BENEFITS: These studies would improve means of testing for disease reaction, provide information upon which to alter cultural practices for increased disease resistance and establish a basis for application of resistance-modifying chemicals. Benefits included under 208-A and 307.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	1	1

TITLE: Epidemiology and Control of Rice Blast Disease. RPA 208-H

SITUATION: Blast, caused by Piricularia oryzae, has long been one of the major disease problems of rice grown in the Gulf States, especially Louisiana. Its seriousness varies from year to year, and from location to location. It causes serious economic losses in some fields each year, and is regularly a limiting factor in certain localities. Considerable work has been done on epidemiology of the blast disease in Asia, yet relatively little has been done in the Gulf States. At present it is not known how or where the fungus overwinters in the United States, nor what are the primary sources of inoculum for infection of the next year's crop. It is not known why certain localities have more blast than others, but soil types, differences in climatic conditions, cultural practices, and sources of overwintering are all factors which might influence this. Although progress has been made in the development of resistant varieties, new races of the fungus have built up and caused severe losses on new resistant varieties within a few years of their release. This indicates the need to develop other means of control which can be used in the event resistant varieties are attacked by new races.

OBJECTIVE: To identify means of overwintering of the blast fungus, sources of primary inoculum, conditions that affect buildup of the disease to epiphytotic proportions, and means of control of the disease.

RESEARCH APPROACHES:

A. Determine methods of overwintering and sources of primary and secondary inoculum, including a study of the possible role of (1) seedborne infection, (2) alternate hosts, (3) airborne spores from the tropics, and (4) infected stubble and straw.

B. Study variations in local humidity-temperature-soil factors and cultural practices and their influence or blast development in different areas.

C. Develop or identify nonhazardous fungicides for control of the rice blast disease, and determine proper times and rates of application. This should be in conjunction with epidemiological studies, so that a disease forecasting system could be developed.

D. Determine effect of soil amendments such as calcium silicate slags (long used in certain areas of Japan) or rice hulls on development of blast disease in problem areas.

E. Coordinate with 208-A, 207-A, 405 and 406.

POTENTIAL BENEFITS: An adequate means of predicting local blast outbreaks and forecasting widespread epiphytotics, together with knowledge of chemical or other means of control would greatly reduce losses from this disease with a minimum of expenditure by the farmer. In localized areas where blast is a problem almost every year, farmers could safely increase fertility rates and realize a 25-50% increase in yield. Areawide yield increases would be approximately equivalent to 1% of the total value of the crop.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Develop Combination Practices to Control Different Complexes of Weeds in Rice. RPA 209-A

SITUATION: Algae, weed grasses, broadleaf weeds, and sedges infest our rice fields. Some of these are annuals, and some are perennials. We classify some as terrestrial weeds and some as aquatics. Variations in the specific species making up the total complex in any one field varies from region to region, and often differs between adjacent fields. Methods that control one complex of weeds may fail completely in another field where the complex of weeds consists of different species.

These weeds reduce yields, reduce quality, increase the cost of producing and harvesting rice, and harbor insects. The presence of some species of weeds often determines how irrigation water is managed, or when fertilizer is applied. Often, these restrictions on cultural practices are significantly objectionable.

We estimate (from data in 1968 Proc. of Southern Weed Conference (p.203); Rice J. 69: 15-20; Rice J. 69: 69-71; and Rice J. 71: 16-30) that weeds reduce the yield of rice by an amount equal to 15% of the current potential. In addition, the cost of the most effective and dependable control practices cost an estimated $16/A in the South to $27/A in the West (weighted average of $18.70/A) if we include cultural practices, herbicides, and costs of applying herbicides.

Current combinations of weed control treatments provide relatively effective control of sesbania, curly indigo, and certain other annual broadleaf, grass, and sedge weeds. They do not, however, adequately control emersed and submersed aquatic weeds, red rice, sprangletop, morningglory, smartweed, and perennial species of several types. Our best chances for effective, practical control of the different complexes of weeds are in the development of combinations involving two or more components such as cultural practices, biological controls, crop rotations, and herbicides. Research is being conducted to improve the efficacy of treatments within the different components of a combination, and to develop improved combinations. Success in this research would enhance our ability to combine different treatments into systems of control aimed at specific weed complexes growing under each of the different environmental conditions involved in producing rice in the different regions of the United States.

OBJECTIVE: To develop imformation that will facilitate the combining of individual weed control treatments into practical systems of control for different complexes of weeds common to the Southern, Southwestern, and Western regions of the United States. Specifically our goal is to reduce losses caused by weeds to no more than 4 to 5% of the potential yield of rice, and to reduce current costs of control by $2.40/A.

RESEARCH APPROACHES:

A. Investigate the ecological effects of different combinations of cropping systems, herbicide rotations, cultural practices and biological control on natural weed infestations.

B. Study different combinations of treatments for efficacy against specific complexes of weeds common in each region where rice is produced.

C. Study combinations of weed control components selected for performance under the different environmental and cultural practices of each of the three major regions of rice production.

D. Coordinate with research in RPAs 207-A, -D, 208-F, 209-B, -C, -D, -E, -F, 307-C, 308-A, -B, -D, -E, 309, and 901.

POTENTIAL BENEFITS: Increased yield, improved quality, and lowered cost of production. Reasonably successful efforts would reduce losses in yield and quality by an amount equal to an estimated 10% of the potential yield of rice. The costs of weed control would be reduced by $5.6 million in producing 2,360,000 acres of rice in the United States. Benefits of RPA 209-B through -E would be largely realized through contributions of RPA 209-A; we would estimate the direct contribution of RPA 209A at 20% of the total benefits of RPAs 209A through -E.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	1

TITLE: Evaluate New Herbicides and Improve the Safety and Effectiveness of all Herbicides. RPA 209-B

SITUATION: A number of herbicide treatments, used in combination with other practices, effectively control some of the weeds infesting rice. However, most of the herbicides have serious limitations in use because of low selectivity, poor weed control under adverse weather conditions, or drift hazards to adjacent susceptible crops. For example, the herbicides applied preemergence may injure rice unless rigid restrictions are made with respect to techniques of water management and seeding. Herbicides now used postemergence for control of grass weeds usually work well only if applied to young, actively growing weeds, and some provide no control of weeds that germinate after the treatment is applied. Soybeans, cotton, tomatoes and certain

types of orchard plants are particularly sensitive to one or more of the herbicides applied postemergence to rice for grass control, and for control of broadleaf weeds. We need additional information on the persistence and movement of herbicides in soil, water, and plants. The best available herbicides and combination treatments are only marginally effective against algae, emersed and submersed aquatic weeds, red rice, sprangletop, morning-glory, smartweed, and perennial grasses and sedges. These resistant weeds plus barnyardgrass are now the primary targets for research.

OBJECTIVE: To obtain information on how new herbicides, new formulations, mixtures and uses of older materials can be used to obtain better control of weeds and reduce hazards and problems being encountered.

RESEARCH APPROACHES:

A. Evaluate new herbicides, new formulations, combinations, and new methods of applying older herbicides for selective herbicidal action against major problem weeds of each production region.

B. Determine minimal quantities of herbicides which may be applied without loss of effectiveness by using mixtures of herbicides, adjuvants, and new application techniques to reduce costs and soil persistence.

C. Investigate the technique of applying herbicides by injection into irrigation water as it enters the field, and explore the efficacy of other new techniques of applying herbicides.

D. Investigate those factors which influence penetration, absorption, and translocation of herbicides in plants to improve activity and selectivity.

E. Conduct research to characterize the persistance and movement of herbicides in soil, water, and plants.

F. Develop techniques for controlling the movement and persistence of herbicides in soil and in irrigation water, and study ways of controlling movement of herbicides from the target area.

G. Coordinate with research of RPAs 209-A, -C, -D, -F, 308-B, -D, and 901.

POTENTIAL BENEFITS: Increase yields and improve quality of rice, ensure optimum use of land and irrigation water by methods safe for rotational crops that follow rice, and reduce costs of production. Benefits from 209-B would be realized in 209-A, and would contribute approximately 30% of the total benefits from 209-A.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	1.5	2

TITLE: Mechanism of Herbicide Action. RPA 209-C

SITUATION: Rice, because it grows in flooded soil during much of the season, differs greatly from our other agronomic crops. These differences present both advantages and disadvantages with respect to the use of herbicides. Both rice and the weeds which infest rice may respond differently to herbicides than do crops and weeds growing in a less aquatic environment. Consequently much of the existing mechanism research, done with crops and weeds growing under cultural conditions different from those of rice, is of limited value with respect to rice. Currently we use both preemergence and postemergence treatments with herbicides to control weeds in rice. These treatments frequently fail to produce the desired weed control, and occasionally damage rice. We greatly need a better understanding of the principles of herbicide action as influenced by the environment, and by differences in the physiology of rice and weeds. Lack of this information is limiting our ability to obtain optimum results from the use of herbicides.

OBJECTIVE: To determine the mode of action and basis of selective toxicity of herbicides as related to the life history, biochemical processes, and responses to the environment in and by rice and specific weeds; and to use this information to increase the efficacy of herbicide usage.

RESEARCH APPROACHES:

A. Determine the effects of herbicides on essential metabolic systems in major weeds, and in rice.

B. Study the influence of various techniques of water management of response of weeds and rice to herbicides.

C. Study the influence of natural variations in environmental factors on the response of weeds and rice to herbicides.

D. Develop and test theories based on the results of 1, 2, and 3 to explain herbicide action and selectivity and to improve techniques for using herbicides.

E. Coordinate with research of RPAs 207-D, 208-G, 209-A, -B, -D, 307-B, and 901.

POTENTIAL BENEFITS: More efficient control of weeds, less injury to rice by control treatments, and reduced problems with respect to pesticide residues in food and feed products. The resultant benefits would be realized through RPA 209-A, and should approxomate 10% of the total benefits of RPA 209-A.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	0.5

TITLE: Comparative Biology, Physiology, and Ecology of Specific Weeds and Rice. RPA 209-D

SITUATION: The weeds which infest rice fields include annual and perennial species of terrestrial, aquatic, and amphibious plants. Several species of algae, a lower form of plant life, are very troublesome in the aquatic environment of rice. Generally, little is known about the elements of their biology, physiology, and ecology which could provide a basis for the exploitation of any inherent weakness by mechanical, chemical, or biological control procedures, or to take increased advantage of superior characteristics of improved varieties of rice. With fundamental knowledge of their competitive characteristics and their requirements for germination, establishment, growth, and reproduction, considerable gains can be made toward better control procedures.

OBJECTIVE: To determine and exploit differences in the biology, physiology, and ecology of problem weeds and rice as a means of improving current control procedures, developing new control treatments, and reducing future weed infestations.

RESEARCH APPROACHES:

A. Study the requirements for germination, growth, establishment, and reproduction by propagules of problem weeds and rice, and evaluate methods of using knowledge of the differences discovered to provide better methods of control.

B. Continue investigations of the ecological and economic aspects of competition between rice and selected species of weeds.

C. Investigate the possibility of increasing the competitive ability and herbicide tolerance in rice through selection of varieties and improved cultural practices.

D. Coordinate with research of RPAs 208-G, 209-A, -B, -C, -E, 307-A, -C, and 901.

POTENTIAL BENEFITS: Increased returns per unit of investment through better yields and reduced weed infestations, and possible reductions in requirements for using herbicides. These benefits should contribute at least 30% of the total benefits to be realized through RPA 209-A.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Control of Weeds by Means Other than Herbicides. RPA 209-E

SITUATION: Although water management is widely used to complement other methods of controlling weeds in rice, opportunities exist for greatly improved control of weeds in rice through refinements in water management, changes in seedbed preparation techniques, development of biological controls for specific weeds, and to some extent through changes in fertilization practices and other cultural techniques. Red rice, johnsongrass, and algae (and other species of aquatic weeds) probably would be targets with high degrees of susceptibility. To achieve significant success we would not have to rely completely on the nonchemical techniques, but might be able to use nonchemical approaches to gain effective control over a species resistant to chemical methods, or we would render many species more susceptible to chemical controls through exposure to nonchemical control pressure.

OBJECTIVE: To improve current use of water management and other cultural practices for control of weeds in rice; and to explore biological agents as possible control measures for specific weeds that are resistant to herbicides.

RESEARCH APPROACHES:

A. Characterize the location of viable weed seed in the soil, and attempt to develop soil handling techniques to control their germination, emergence, and viability.

B. Evaluate the use of insects and plant disease organisms for control of specific weeds that are resistant to current methods of control (including domestic organisms, and foreign insects and diseases through PL 480 research).

C. Study the timing of fertilizer applications with respect to favoring rice at the expense of various species of problem weeds.

D. Evaluate new techniques in water management to provide better direct control of weeds, and to develop better complementary action with other methods of control.

E. Coordinate with research of RPAs 207-B; 208-E, -F; 209-A, -D, -F; 307-A1, -B1, -B2, -C1, -C2, -C3; and 308-A, -D, -E.

POTENTIAL BENEFITS: Decreased production costs, decreased yield losses due to weeds, and decreased problems associated with the use of herbicides to control hard-to-kill weeds. Approximately 10% of the total benefits expressed in RPA 209-A would results from RPA 209-E.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	0.5

TITLE: Techniques for Repelling and Excluding Birds, Rodents, and Other Wildlife. RPA 209-F

SITUATION: Birds and rodents often cause damage to plantings of rice. For example, young seedlings may be destroyed, and developing and matured grains eaten or shattered by any of these pests. Noisemaking devices, scarecrows, recordings of bird distress calls, predator scents and other chemical repellents, trapping, dynamiting of roosts, poisoning, and shooting are used to repel, exclude, and kill birds and other wildlife. Methods which destroy the offending wildlife are highly controversial. Other methods are generally either low in effectiveness, expensive, of poorly adapted for use in large fields. Although we are currently unable to quantitate losses in rice caused by birds and other wildlife, we do have data to indicate that the losses are significant. Biologists of the Fish and Wildlife Service reported estimated losses of 1.3 bu/A caused by birds in Arkansas. Losses caused by muskrats in Arkansas rice fields were estimated at $800,000 in 1966, and at $900,000 in 1967. On the other hand, wildlife particularly the bird population, is beneficial in some respects. The diet of birds includes significant proportions of harmful insects, weed seed, and other pests that affect rice.

OBJECTIVE: To identify, characterize, and mitigate losses caused by birds, rodents, and other wildlife without endangering the balanced existence of any species involved.

RESEARCH APPROACHES:

A. Identify the exact species of wildlife involved in specific situations, and measure the benefits and losses they cause in these situations.

B. Investigate different types of flashing lights, recorded sounds, moving mechanical men and predatory animals, and other nonchemical techniques as repellents.

C. Develop safe, economical repelling chemicals.

D. Characterize the economics of public reimbursement of individuals sustaining severe losses in locations adjoining wildlife refuges.

E. Investigate the potential of breeding rice for resistance to damage from wildlife.

F. Investigate the potential of using controlled sterilization to reduce overabundant local populations of depredating species, such as blackbirds, starlings, and sparrows.

G. Coordinate with research of RPAs 209-A, 307-A, and with similar research associated with other crops.

POTENTIAL BENEFITS: Reduction of losses in stands and yields. Although we have little data for quantitating the losses, crop scientists and wildlife specialists estimate that current annual losses in rice are approximately 1% of the crop. We could logically expect to reduce these losses by 25%.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Rice Improvement Through Breeding and Genetics. RPA 307-A

SITUATION: The development and use of improved rice varieties resulting from genetics and breeding research has contributed greatly to the dramatic increases in rice yields. Improvement of milling and cooking quality; resistance to diseases and insects; fertilizer responsiveness; maturity, height, and other agronomic characteristics; and nutritive content are factors under genetic control that are incorporated into rice varieties. Yet much more can be accomplished. Research on short, upright leaf, stiff-strawed, fertilizer responsive types that are more photosynthetically efficient needs to be accelerated. The development, use and feasibility of F_1 hybrids need to be exploited. Improved breeding procedures, methods to increase gain per breeding cycle while reducing cycle time need to be identified. The establishment of a system of multigenerations a year, utilizing tropical or semitropical climate, is critically needed. Complete utilization of information on basic physiological processes to improve yield and quality depends upon research in genetics and breeding.

OBJECTIVE: Develop through breeding, higher yielding rice ecotypes which have desired agronomic, milling, cooking and processing qualities.

RESEARCH APPROACHES:

A. Improve yield, cooking and milling quality, fertilizer responsiveness, disease and insect resistance, and desirable agronomic characteristics through hybridization, screening and the release of improved varieties.

B. Determine through genetic studies the magnitude of hybrid vigor and develop cytoplasmic male sterile counterparts and nuclear restorer lines making F_1 rice hybrids feasible.

C. Determine photosynthetic efficiency, its heritability and use in developing superior plant types. Incorporate greater photosynthetic efficiency into short-statured, upright leaf, stiff-strawed high-yielding types.

D. Investigate and develop improved breeding methods and procedures; inaugurate multigenerations per year cycle to gain time and efficiency.

E. Identify and develop methods for determining varietal reaction to micro and macro climate and study genetic responsiveness to these factors.

F. Coordinate with research in RPAs 207-A; 208-A, -B, -F; 209-D, -F; 307-B, -C, -D; and 405-A.

POTENTIAL BENEFITS: Improvement in genetic potential for yield would be made. Utilization of heterosis manifested in F_1 hybrids can be expected to increase yields 15 to 30%. Development of types varying in protein and other constituents could result in expanded usages.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
10	12

TITLE: Chemistry of Flooded Soils. RPA 307-B1

SITUATION: The anaerobic and chemically reduced root zone of the soil in which lowland rice is grown differs greatly from the root zone of a well-drained soil. The reduced conditions in rice soils affect the growth of the rice plant and the availability of several plant nutrients. A better understanding of how the rice plant is affected by reducing conditions and how native and added plant nutrients react in waterlogged soils is needed. We also need to know the chemical processes taking place in waterlogged soils and how these processes affect the growth of the rice plant and the availability of plant nutrients.

OBJECTIVE: To obtain basic information on chemical processes taking place in soils as a result of waterlogging that are of importance to the growth and nutrition of the rice plant.

RESEARCH APPROACHES:

A. Determine the effect of waterlogging on changes in both inorganic and organic chemical systems in the soil

B. Characterize the reactions that occur between components of different oxidation-reduction systems in waterlogged soils and determine the effect of these reactions on the nutrition of the rice plant.

C. Study the effect of reduced chemical systems in waterlogged soils on the availability of plant nutrients to the rice plant.

D. Determine the production of substances in waterlogged soils that are toxic to the rice plant and ascertain means of correction. Also determine the effect of straw incorporated in the soil on the production of toxic substances.

E. Measure the effect of different intensities of reduction caused by waterlogging on growth and development of the rice plant.

F. Study the effect of waterlogging on denitrification losses of nitrogen from the soil.

G. Determine the factors involved in fixation and release of phosphate in waterlogged soils.

H. Coordinate with research under 307-B2; 307-C1, 2 and 3; and 407-A and -B.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Improved growth and yield of rice; improved utilization of plant nutrients. A better understanding of chemical environment of the rice plant will result in higher yields through improved nutrition and more effective fertilization. An estimate of the benefits from these practices is given in 307-B2.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1.0	2.0

TITLE: Nutrition and Fertilization of Rice. RPA 307-B2

SITUATION: Fertilization practices for rice differ from those of other crops because of physiological differences in the rice plant and also because some plant nutrients are in a different form in a flooded soil than in a well-drained soil. Nitrogen nutrition and fertilization of rice is especially critical since nitrogen is generally deficient in rice soils and a large amount of nitrogen (about 120 lb/A total) is needed by the crop from soil and fertilizer sources of maximum production. Present United States varieties are limited in the amount of nitrogen they can utilize due to the danger of lodging. Development of shorter, stiff-strawed varieties which are being actively sought by plant breeders will require additional studies on the optimum amounts of fertilizer nutrients especially nitrogen. Unlike nitrogen, which is subject to increased loss as a result of flooding, phosphate is more available under waterlogged soil conditions than under well-drained conditions. Certain micronutrients, iron and manganese, for example, are usually increased in availability by waterlogging, sometimes to the point of toxicity, while the availability of others may be decreased by waterlogging. Information gained on the reactions of both major nutrients and micronutrients in well-drained soils is of little value in predicting their reactions in waterlogged soils. Growers cannot determine the optimum rate

of fertilizer that should be applied. Development of methods to evaluate the nutritional requirements, especially for nitrogen, are urgently needed.

OBJECTIVES: To determine the physiological response of the rice plant to various combinations of major and micronutrients and to determine the yield response of both present and new varieties to various forms of plant nutrients. To develop an accurate method of soil and tissue analyses to be used by growers in determining fertilizer requirements and to identify nutrient deficiencies.

RESEARCH APPROACHES:

A. Measure the yield response of new and existing varieties of rice to both major and micronutrients under different soil and climate conditions.

B. Study the physiological response of the rice plant to various nutrients, especially nitrogen, applied at different times to determine their effect on vegetative and reproductive growth.

C. Investigate various methods of placement and incorporation of plant nutrients in the soil to obtain maximum yield response.

D. Evaluate new forms of fertilizers and new methods of controlled release of fertilizer nutrients to improve the response of rice to plant nutrients.

E. Determine the best fertilization system to use for ratoon or double cropped rice (two crops harvested from one planting).

F. Study the effect of fertilization on amino acid composition and protein content of rice.

G. Devise treatments for soils with saline, alkaline or calcareous soil conditions that occur naturally or as a result of poor quality irrigation water.

H. Develop methods of soil analysis and plant tissue analysis by which reliable predictions of fertilizer requirement can be made.

I. Determine the effect of biocides on chemical processes in water-logged soils.

J. Coordinate with research under 307-A; 307-B1; 307-C1, 2 and 3; and 407-A and -B.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Increased yield and quality of the crop and/or decrease cost of production.

An increase in yield of 300 lb/A.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
2.0	2.0

TITLE: Soil Management. RPA 307-C1

SITUATION: The development of larger tractors and implements, effective weed control practices, precision leveling of rice fields, and water seeding of rice by airplane have changed the traditional methods of tillage and seedbed preparation. A smooth, well-worked seedbed may not be as essential as in the past. Adequate power is now available so that the soil can be worked deeper.

OBJECTIVE: To investigate various methods of tillage and seedbed preparation for rice utilizing the latest developments in tillage equipment, fertilizer application, weed control, seed treatment and seeding methods.

RESEARCH APPROACHES:

A. Compare the effectiveness of various tillage tools for plowing, seedbed preparation and straw incorporation. Measure their effect on stand of crop and yield.

B. Compare conventional methods of seedbed preparation with minimum tillage and no tillage methods.

C. Study land preparation in the fall with overwinter flooding as a method of conserving nitrogen and irrigation water.

D. Evaluate longtime effects of increasing the root zone of the crop by deep tillage and deep incorporation of crop residues.

E. Determine the effect of various rotations, including growing rice every year and straw incorporation, on the soil organic matter content and soil structure.

F. Coordinate with research under 307-B1 and 2; 307-C2 and 3; and 308-A.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Increased yields and/or lower land preparation costs.

An increase in yield 100 lb/A.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1.5	1.5

TITLE: Water Management. RPA 307-C2

SITUATION: Although keeping the rice field flooded is recognized as an essential practice in lowland rice culture, only a limited amount of research has been done on determining the benefits to be derived from flooding and on improving the efficiency of water use. Water supplies are likely not to be as plentiful in the future as in the past and information is needed on methods of improving the efficiency with which water is used.

OBJECTIVE: To develop methods by which the efficiency of irrigation water usage can be improved.

RESEARCH APPROACHES:

A. Compare season-long flooding of rice fields with intermittent periods of flooding.

B. Determine the optimum depth of floodwater for different varieties especially shorter plant types.

C. Study overwinter flooding of rice fields as a means of conserving superior quality irrigation water, especially where water quality is a problem. Also study effect of overwintering on yield of following crops, both rice and rotation crops.

D. Determine if effective chemical weed control and maintenance of an adequate supply of available water without submergence of the soil can replace flood irrigation.

E. Determine the effect of better management of irrigation water on the utilization of plant nutrients. Specifically, this will involve measurement of nutrient loss caused by draining.

F. Determine the effect of industrial wastes in water on the growth and yield of rice and on soil properties.

G. Devise methods of improving the quality of irrigation water before it is applied to the field.

H. Coordinate with research under 209-A and -E; 307-A; 307-B1 and 2; 307-C1 and 3.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: More efficient use of water and/or higher yields.

An increase in yield of 100 lb/A.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	0.5	1.0

TITLE: Crop Management. RPA 307-C3

SITUATION: Recent developments in weed control, fertilization and seeding practices have caused changes in the traditional methods of management of the rice crop. Most of the present methods of management were based on the use of small amounts of fertilizer with the crop obtaining a significant amount of nitrogen from rotation crops such as grass-legume pasture. With the use of higher amounts of chemical fertilizer and more effective weed control such rotations may not be of the same value as in the past.

OBJECTIVE: To determine the best system of management of the rice crop so that continued high yields can be economically obtained.

RESEARCH APPROACHES:

A. Compare continuous rice with other rotations of rice and other crops to determine if the benefits which accrue from the use of rotations can be obtained from the use of superior production practices such as a high level of fertilization and effective weed control.

B. Determine the best varieties for double cropping.

C. Determine the planting date for maximum yield for existing and new varieties. Determine the value of planting at a date that will give maximum radiant energy to the crop.

D. Devise planting methods that will result in improved seedling survival and more vigorous early growth.

E. Develop methods to neutralize germination inhibitors in order to obtain better stands of rice.

F. Determine the effect of growth regulating chemicals on yield and growth habit of the crop.

G. Coordinate with research under 209-A; 307-A; 307-B1 and 2; 307-C1 and 2.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Increased yields and improved efficiency of production.

An increase in yield of 50 lb/A.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1.5

TITLE: The Role of Microclimate in Rice Production. RPA 307-D

SITUATION: The microclimate in a rice field is unique among cultivated crops because the soil is flooded during most of the growing season. This obviously causes higher relative humidities within and above the rice canopy but also it may influence many other environmental elements such as air and soil temperature, light, carbon dioxide concentration and net radiation. These factors in turn affect the rice plant directly by governing photosynthesis rate, respiration, starch accumulation, pollination and seed maturation, and indirectly through their influence on disease and insect outbreaks and buildups. The flooding and draining of rice fields therefore is an effective means of manipulating the microclimate of the crop to a greater extent and to more timely advantage than is possible with other crops. Previous investigations and observations indicate that nighttime temperatures in the 50 to 55 degree F range during flowering in rice result in greatly reduced seed set and yield. Other environmental and/or physiological conditions in absence of low temperature also cause low seed set but the exact conditions are not known. Abrupt temperature changes also appear to affect seed set, grain yields and quality. Some microclimate studies have been made in the orient on hand transplanted rice but only preliminary, minimal instrumented studies have been made on rice grown in our direct seeding system of culture.

OBJECTIVE: To characterize the microclimate in rice fields during the growing season and relate each facet to growth and pollination processes in the plant and determine the sensitivity of each facet to climatological changes or modification of cultural practices.

RESEARCH APPROACHES:

A. Assimilate from existing climatological and agronomic data the climatological or meteorological factors that appear to affect growth and pollination of rice most substantially.

B. Determine the profile of temperature, humidity, light, and net radiation in rice plots throughout the growing season with several varieties and cultural regimes with intensive characteristization of growth, pollination, diseases, and insect buildup in the same plots.

C. Determine insofar as possible the effect of abrupt temperature changes on seed set, grain yields, and quality.

D. Select varieties, row spacing, water management practices, etc. to optimize the microclimate for plant growth, maximum yield, and quality as predicted by long and short range weather forecast.

E. Coordinate with research in RPA 207-A, 207-D, 208-C, 208-H, 209-A, 307-A, 307-C, 308-A, 308-C and 405-A.

POTENTIAL BENEFITS: Growers could make management decisions based on long term probabilities rather than from memory of the preceding one or two seasons. Breeders could select varieties with maturity dates and growth characteristics to take maximum advantage of climate of a particular region. Disease and insect control measures could be more effectively and timely applied. Fertilizer application could be timed for most efficient uptake and utilization.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Development of New Rice Soil Tillage Equipment. RPA 308-A

SITUATION: Practically all tillage equipment used in rice production and harvest was developed for crops other than rice. Rice production is unique in that large quantities of water are used in irrigation with resultant wet field conditions much of the year. Many land preparation and tillage operations are done in water or under wet conditions. Much of the tillage equipment now used in rice production was not designed to be operated under such severe conditions, consequently depreciation is high and efficiency low.

Also of importance is the need to remove or otherwise dispose of crop residue. Traditionally, the straw has been burned or baled then removed. Restrictions on burning due to pollution are becoming more severe, limiting this means of disposal.

There is a need to develop equipment, specifically for rice soil tillage, designed to operate in water and under wet conditions, and to incorporate into soil, or otherwise dispose of crop residue.

OBJECTIVE: To develop equipment specifically for rice soil tillage.

RESEARCH APPROACHES:

A. Develop equipment for optimum tillage specifically for rice production.

B. Develop tillage techniques for land preparation in flooded soils.

C. Develop equipment for incorporating crop residue into soil.

D. Coordinate research with RPA 307-C1.

POTENTIAL BENEFITS: Tillage equipment developed for rice production could reduce capital and depreciation cost, and improve field efficiency, and yields. This could result in substancial annual input cost savings.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	1

TITLE: Development of Improved Chemical Application Equipment. RPA 308-B

SITUATION: Chemical use on rice has increased substantially in recent years and is expected to continue to increase in the forseable future. Most chemicals, including insecticides, herbicides, and fertilizers are applied by use of airplanes. However, there is need for research on the development and use of ground equipment for application of chemicals prior to flooding and during the growing period at which time the soil is covered with irrigation water. As pre-emergence chemicals are developed for rice there will be an expanded need to develop and evaluate application equipment.

OBJECTIVE: To develop more efficient and effective chemical application equipment for rice production.

RESEARCH APPROACHES:

A. Studies to develop new techniques for applying chemicals to rice.

B. Develop new equipment for application of chemicals to rice.

C. Coordinate research with RPA 209 and 307.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: More uniform application of chemicals would result in savings through reduced application rates. New techniques and equipment for application may result in higher yields and less application cost. A 3% increase in yields could result from better application of all chemicals used in rice production.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Development of Improved Harvest Equipment. RPA 308-C

SITUATION: Rice is harvested in the United States by use of self propelled combines. Lodging is quite common in rice and large quantities are lost due to shattering during the "pick up" of the lodged rice. Well adjusted combines in good condition, leave about 1% of the crop in the field, while poorly adjusted, usually older machines, lose more. One observer found as much as 14% of the crop left in the field and lost due to poor combine operation and adjustment. Additional losses occur during transfer to transport vehicles. Much of the riceland is poorly drained and presents problems of mobility for combines and transport vehicles.

There is a need to develop techniques for combine evaluation and adjustment, as well as development of equipment to more effectively recover lodged rice. There is also need for development in field transport vehicles to reduce labor requirement and increase mobility.

OBJECTIVE: To develop new harvest and field transport techniques and equipment.

RESEARCH APPROACHES:

A. Develop standardized harvest techniques to improve efficiency of combine operations.

B. Develop improved pick up equipment and more mobile combines.

C. Develop improved field transport equipment with better mobility requiring less labor.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Improved techniques and equipment for rice harvest would recover more rice now lost, with saving in labor during peak harvest periods. A savings of as much as 3% of the crop may be gained by improved harvest equipment.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	1

TITLE: Analysis of Economic Forces Contributing to Farm Size Enlargement (Firm Growth) and Related Problems. RPA 309

SITUATION: A persistent trend in American Agriculture for the past several decades has been the increasing size and expanding volume of business per farm unit. Farms in the rice areas reflect these adjustments. This process is fostered by a number of forces, both internal and external, of the farm organization itself. Modern production techniques now require farmers to spend 70 to 80% of their gross income dollar for off-farm inputs compared with only about 50% in the early 1950's. The specific inputs being purchased (including labor) are highly specialized and to insure optimum returns their effective use requires a high degree of managerial skills. The marked increase in capital requirements (for annual production as well as long run investment) places greater emphasis on such problems as risk and uncertainty, the equity position which lending institutions associate with a sound credit risk, and on keeping capital repayment schedules in balance with dependable income flows. Farmers need better information on how weather risks can be reduced by maintaining equipment inventories and labor numbers at adequate levels for timely operations, and on the magnitude of cost reductions attainable through increasing size of units. Finally, the farm manager needs guidance in making rational decisions relative to long term management of assets, including intergeneration transfers at nominal costs.

OBJECTIVE: To better understand and evaluate the factors that contribute to the process of firm growth in the major rice producing areas.

RESEARCH APPROACHES: In essence this research involves an extension of short-run adjustments, which are concerned largely with attaining optimum returns each season, into a long-run family living cost-capital investment plan which allows for maximum asset accumulation over time. As a base of departure, input-output data from previous surveys will be used to gauge normal whole farm returns under average weather conditions and assumed prices received. These determinations will be made to reflect various levels of machinery technology now in use. To this will be added the dynamics of a polyperiod model by simulating the effects of several weather patterns (normal, good, and unfavorable) occurring in a random fashion on income flows when such chance variations are coupled with varying operating strategies that a farm manager may follow. Such alternative operating strategies would be designed to reflect conventional management decisions relative to a number of key factors such as : (1) the share of annual income flow that is to be drained off through consumer expenditures, (2) the level of equipment inventory to be maintained as a safety factor against crop losses resulting from unfavorable weather, and (3) use of alternative depreciation schedules and tax management programs available to the operator. The results obtained through linear programming should identify courses of action that would contribute most to capital accumulation.

POTENTIAL BENEFITS: Aid farmers in long term capital management, reduce fluctuation in net farm incomes, and stabilize volume of credit required to finance agricultural production. Benefits would accrue to farmers, lending institutions, agribusiness firms, and agency planners and administrators, and cannot be expressed accurately in dollar values.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	2

TITLE: Breeding Improved Varieties with Better Consumer Acceptance. RPA 405

SITUATION: Although the United States produces less than 1% of the free world's rice, it is currently the number one exporter of rice. The annual U.S. per capita rice consumption is 7.3 pounds with 22% of this amount being in the form of speicalty and convenience products. The consumption of these specialty and convenience products increases yearly. Improving consumer acceptability will increase the number of consumers and per capita consumption, while not adversely affecting the number of heavy rice users. Physical characteristics of the rice grain such as color, shape, size and texture influences attractiveness and consumer acceptance. Nutritional qualities, whether increased for greater food value or decreased for dietary advantage, stimulate consumer acceptance. Flavor also affects consumer preference. All of these physical and chemical characteristics are largely under genetic control and through breeding techniques may be incorporated into new varieties. Research by food processors and utilization laboratories, must be closely coordinated with that of production scientists.

OBJECTIVE: To obtain information on current and longer range needs of the rice industry and incorporate the desired qualities into new rice varieties to increase consumer acceptability.

RESEARCH APPROACHES:

A. Develop through breeding and genetics rice varieties with improved milling, cooking, and processing characteristics.

B. Develop varieties resistant to smut, stink bug and tolerant to environmental factors adversely affecting quality.

C. Develop adapted varieties with unusual grain sizes, shapes, aromas, flavors and other organoleptic characteristics having broader consumer appeal. Develop techniques for measuring these grain characteristics.

D. Develop varieties specifically suited for sale in major foreign markets.

E. Coordinate with research in RPAs 207-A; 208-A, -B, -F; 209-D, -F; and 307-A, -B and -C; and 407-B and 416.

POTENTIAL BENEFITS: The development of varieties with improved appearance and of all the types required for types of consumer needs, will cause a substantial increase in the value of the crop.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
2	3

TITLE: New Practical Procedures for Increasing Rice Milling Yields. RPA 406-A

SITUATION: Improvement of rice milling by increasing yields of head rice (whole kernels) and of total milled rice is of critical importance to the industry. The world's rice consuming peoples prefer whole grains and will pay almost twice as much for them as for broken kernels, and in direct contrast to most other cereal grains, rice is seldom consumed as flour, A potential market for broken rice.

Improvements in equipment and processing, such as sophosticated abrasive mills and solvent milling, have increased milling yields. However, premilling treatments to seal cracks, and the use of chemicals to soften the interface of the bran and endosperm and to harden the outer portion of the endosperm, could result in further improvements in economy and efficiency in bran removal without causing endosperm breakage. Closely related is the need for development of methods for increasing total milling yield by prevention of loss of white endosperm in polish, bran or hulls.

OBJECTIVE: To increase head and total rice yields during milling.

RESEARCH APPROACHES:

A. Develop methods for increasing head rice yield by chemical pretreatments.

B. Bring about increased head rice yields by physical pretreatments.

C. Investigate enzyme activity for softening bond between bran and endosperm.

D. Develop methods for removing less of the white outer layer of the endosperm during milling.

E. Develop equipment for milling indicated by A, B, C, and D in cooperation with industry.

F. Coordinate with research of RPA 307-A,-B2, -D; 405; 408-A, -B; and 504-A

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Increase in milling yield of head and of total milled rice. Increased product value resulting from an increase in head rice yield as much as 5% of rough rice plus an increase in total milling yield of as much as 3%.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
2	2

TITLE: Induced Alterations in Processing Characteristics. 406-B

SITUATION: Rices grown in the U.S. and abroad vary widely in their cooking and processing characteristics. Consumer preference usually follows the characteristics of the locally grown varieties. Development of a practical process for altering the plasticity and cohesive characteristics of the various varieties of short-, medium-, and long-grain rices so that they are more acceptable to specific prospective consumers in any locality should increase domestic utilization and foreign acceptance of U.S. rice. Alteration of rices by processing of even a fraction of the total production to resemble more desirable types would assist in broadening the rice market. There is ample evidence in recent research reports that rice cooking characteristics are altered during storage at ambient temperatures and that similar changes can be induced by mild steam treatments. More drastic changes are commonly induced by parboiling. A system of processing designed to modify all varieties is needed to satisfy diverse market requirements.

OBJECTIVE: To devise methods for treating rice to alter its cooking and processing characteristics for use by specific consumers.

RESEARCH APPROACHES:

A. Investigate heat or heat-chemical treatments of rice to accelerate changes normally associated with aging.

B. Develop a processing system for changing the plasticity of rice to alter its cooking characteristics by combinations of heat-pressure-moisture treatments.

C. Investigate high energy radiation, gamma irradiation, or gas plasma to induce alteration of processing characteristics.

D. Identify the rice constituent(s) affected when processing change occurs.

E. Coordinate with research of RPAs 307-A and 405.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Expansion of the domestic and foreign utilization of domestic rice by supplying more acceptable and uniform products to specific markets.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Enriched Milled Rice Products. RPA 406-C

SITUATION: Milling reduces the nutritive value of brown rice; thus fortified or enriched new rice products formulated to meet the needs of, or to supplement other foods available in a particular locality are essential in areas where rice is the principal food. Means for making an acceptable product by either uniformly coating rice with selected vitamins, minerals, protein, protein hydrolyzates or amino acids into acceptable rice products or impregnating these nutrients into the rice kernel is needed, to correct dietary deficiencies of rice-eating peoples. Present techniques are unsatisfactory because either 0.5 lb/cwt is heavily fortified and coated by water insoluble films and then blended with 99.5 lbs. of milled rice which present identifiable differences in the fortified material; or the vitamin-mineral supplement is added without protection against loss by washing, or by cooking in an excess of water. A uniformly enriched product, stable to washing, and providing more supplementary nutrients is needed.

OBJECTIVE: To develop improved enriched rice or enriched rice products.

RESEARCH APPROACHES:

A. Enrich rice by treatment of the kernels to allow impregnation of nutrients.

B. Enrich rice by encapsulation or mordanting nutrients onto the grain surface.

C. Enrich rice by processing rice or rice flour and incorporating nutrients prior to reconstituting into a new-formed rice product.

D. Enrich rice by reintroduction of pulverized stabilized rice bran or highly nutritive bran fraction.

E. Coordinate with research of RPA 307-B2 and 405.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: New outlets for rice where nutritional value is recognized or essential, due to superior formulation and product acceptability. Such a product would be an added weapon in the fight against world hunger.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	1

TITLE: Stabilization and Improvement of Brown Rice. RPA 406-D

SITUATION: Brown rice, unlike milled white rice or paddy (rough) rice, deteriorates quite rapidly in flavor and aroma on storage at ambient temperatures with an accompanying increase in free fatty acid content. Freshly dehulled brown rice has a pleasant nut-like flavor and is nutritionally superior to white milled rice. Stabilization of the initial flavor and aroma by development of a process using chemical or physical treatments at a cost not to exceed the cost of milling plus the added value of the bran fraction, should yield a product of excellent market potential, domestically and especially for export. Brown rice has a dull off-white color as compared with the white milled product. This off-white or yellowish color has, in the past, been associated with poor quality usually attributed to improper storage. The latter problem may be solved by decolorizing the bran or it may disappear as an objectionable characteristic with the development of a good brown rice product that is flavor and aroma stable for six months or more.

OBJECTIVE: To develop a storage-stable brown rice having good flavor, aroma and appearance.

RESEARCH APPROACHES:

A. Stabilize brown rice flavor by development of coatings containing fats, fat derivatives, proteins and antioxidants.

B. Develop chemical or physical treatments designed to inactivate lipases and lipoxidases to stabilize brown rice.

C. Develop chemical treatments to decolorize brown rice.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS:

(1) Introduction of a new highly nutritious product of acceptable flavor that will increase the comestic market for rice.

(2) Elimination of milling costs and breakage during milling.

(3) Increase in the acceptability of exported brown rice.

(4) Increase in the proportion of the kernel used as food.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	0.5

TITLE: Improvement of Flavor and Aroma of Rice and its Processed Products. RPA 406-E

SITUATION: The average domestic rice consumer describes rice flavor as bland or flavorless, however, aroma and flavor are important for acceptance. For example, if no aroma developed during rice cooking or if off-odors or flavors such as those attributed to staleness are detectable the rice would probably be discarded. Acceptance of processed convenience rice products is considered to be limited by the lack of these flavor and aroma attributes. Little is known about the chemical compounds involved in the flavor and odor of cooked rice although several odoriferous compounds have already been identified in the confined headspace above cooked rice, and some evidence has been presented that fat deterioration may be responsible for off odors or flavors. Knowledge of the means of generation of normal and off flavors and odors and identification of their chemical components should result in the development of more acceptable natural and processed products and the development of new products of enhanced flavor and odor.

OBJECTIVE: To improve flavor and odor of rice, processed rice products and to develop new improved products having enhanced flavor and odor.

RESEARCH APPROACHES:

A. Develop edible coatings to retain and stabilize natural flavors and aromas.

B. Identify chemical compounds responsible for natural and desirable flavors and odors.

C. Develop methods for enhancing flavor of processed rice convenience products.

D. Coordinate with research of RPA 405.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Improvement of flavor and aroma of rice would strengthen markets for rice and assist in increasing its per capita comsumption.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	0.5

TITLE: Development of New Processed Products. RPA 406-F

SITUATION: Per capita consumption of rice in the U.S. has increased about 25% (1.5 lb) in the past ten years. Most of the increase has been in processed convenience-type products, of which a major one is quick-cooking (precooked) rice. Inefficient cooking, washing and drying processes cause large losses of flavorful soluble solids and much breakage, with resulting high costs. Reduction of total product costs and losses may be possible by application of process inovations from other industries. There is also a wide potential for increasing the variety and reducing costs of the few frozen rice foods now marketed. Additionally, there is an unexplored possibility for making rice foods with characteristic properties and flavors by malting and fermentation processes.

OBJECTIVE: To expand consumption of rice foods by developing new processes and an increased variety of improved, uniformly high quality, and lower cost rice products.

RESEARCH APPROACHES:

A. Investigate process innovations for diminishing losses of solids and flavor and reducing costs in making quick-cooking rice.

B. Determine relations of composition and surface properties of over-milled medium-grain rices to suitability for preparing quick-cooking rices.

C. Devise cost-reducing processes for developing a variety of frozen rice foods.

D. Study potentials of developing rice foods based on malting or fermenting processes.

E. Cooperate with industry in A, B, C, and D, and in evaluating procedures developed in this research.

F. Coordinate with research of RPA 307-A and 405.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Continued expansion of rice markets would result from the availability of convenience type processed rice foods at reduced cost and with improvement in variety and quality of products offered.

RESEARCH EFFORTS:

T F RECOMMENDATION	
1972	1977
0.5	2

TITLE: New Uses for Rice Flour. RPA 406-G

SITUATION: Because rice is traditionally eaten as whole grains, its potential uses in flour form have been inadequately explored. Some flour is produced from broken kernels and used in baby food, prepared mixes, and as an additive to other cereals for breakfast foods. Flour from waxy rice, a very minor crop, has special uses in frozen sauces and gravies. The highly nutritive protein in these flours occurs in the same low concentrations as in the original kernels. Now a high-protein flour (15-20%) can be prepared from white rice by simple abrasive milling with available machinery. The product is a highly nutritious, essentially non-allergenic protein food enchanced in vitamins, fats, and minerals. It would serve a most important function in nourishing infants and preschool children throughout the world - as well as adults with special dietary needs. For example, attractive high-protein beverage bases resembling non-fat dry milk in nutritional and use properties can be developed from the high-protein rice flour. The bland flavor of these rice flours does not detract from flavors of other foods in mixtures, but allows a wide potential for added flavorings.

OBJECTIVE: To develop new uses for rice flours in formulated food products.

RESEARCH APPROACHES:

A. Develop nutritious milk-like beverages based on high protein rice flour for infant feeding.

B. Develop rice flour gruels, custards, puddings and other soft foods for use by young children, convalescents, elderly persons, and those with allergies to other cereals, eggs, and milk.

C. Examine the potential for rice flours as ingredients in or bases for baked goods and pasta products.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: High-protein flour could provide an important new food for the improvement of protein deficient diets of children worldwide. Residual kernels from medium-grain rices would be whiter and have cooking qualities more like the prepared long-grain rices; this could increase their relatively low sales price. Increasing the value of small broken pieces by expanded uses as flour would decrease milling costs placed on whole-grain rice.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	1

TITLE: New Food Uses for Rice Milling Fractions. RPA 406-H

SITUATION: Rice bran and polish, comprising about 10-11% by weight of rough rice, have high nutritional value as is shown by their amino acid analyses. They are extensively used in livestock and poultry feed. A comparatively small proportion of high quality polish is indeed now used in baby foods. Bran, usually including some hull fragments, contains too much fiber for general food use. Improvement or modification of the properties of these potential nutritious protein sources would aid in meeting low-cost protein needs not only in the United States but throughout the world. Needed are improvement in stability and minimization of microorganism and fiber contents.

OBJECTIVE: To develop suitable food uses for rice polish and other fractions obtained from rice bran, to provide added sources of low-cost nutritious protein foods.

RESEARCH APPROACHES:

A. Devise procedures for improving the stability and minimizing the microbial breakdown of rice polish.

B. Investigate methods for preparing high-protein low-fiber products from rice bran.

C. Utilize the compositional and functional properties of these upgraded milling fractions, both as entities and as combinations with other ingredients, in providing esthetic and nutritional foods.

D. Cooperate with industry in A, B, and C, and in evaluating procedures developed in this research.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Rice bran and polish offer potential sources of modestly priced high-quality protein for human consumption. By utilizing this protein directly, instead of passing it through the animal protein cycle, large additional amounts of low-cost nutritious protein foods could be made available for meeting the urgent world needs.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	0.5	1

TITLE: Improved Methods of Rice Drying. RPA 408-A

SITUATION: The rice harvest season has become shorter and shorter in recent years, due largely to the limited number of varieties, improved planting, and harvest techniques. Commercial and farm drier operators find themselves in the position of refusing or limiting rice receipts and indirectly forcing the producer to allow his rice to remain in the field longer than desirable, resulting in loss of quantity and quality of his product.

The custom or commercial operator is in the position of being unable to economically justify additional capital outlays for increased drying facilities that can only be used possibly for thirty to forty-five days per year. Overloading of existing drying facilities in many cases, results in damage due to the inability to dry properly.

There is a need for research and development of improved equipment for faster and more efficient rice drying in order to maintain quality and quantity of the product.

OBJECTIVE: To determine optimum conditions and develop equipment to dry rice faster and improve quality in drying.

RESEARCH APPROACHES:

A. Determine more exactly the conditions affecting drying.

B. Development of mathematical expressions for drying.

C. Develop techniques and equipment to dry faster and maintain or improve quality during drying.

D. Coordinate research with RPA 406-A.

CHARACTER OF POTENTIAL BENEFITS: Reduce loss of quality and quantity of the product during drying. The results of this research should partially eliminate losses and improve quality by allowing harvest at the optimum time, and relieve some congestion and loss of quality during the drying process.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Improved Methods of Rice Storage. RPA 408-B

SITUATION: Rice storage is largely in the rough form and in bins designed by use of traditional engineering assumptions and methods. Information is needed to determine optimum environmental conditions of storage for rough, brown, and milled rice. Storage of brown, rather than rough rice, could result in saving of about 20% by weight and 35% by volume in the storage structures.

Research is needed to develop new types and configuration of storage structures, in order to optimize the storage component of the handling and marketing system.

OBJECTIVE: To determine optimum environmental conditions of temperature, air flow rates, and moisture content affecting storage of rough, brown and milled rice. To develop optimum systems of storage to reduce cost of this component.

RESEARCH APPROACHES:

A. Develop equipment and techniques to store brown, rough, and milled rice to maintain quality.

B. Develop basic engineering information required to design storage structures at lower cost.

C. Investigate environmental conditions in rice storage.

D. Coordinate with RPA 408-C.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: The primary benefits of improved storage could result in the ability to more efficiently store, transport, and market brown and milled rice. Improved storage of rough rice could result in reduced drying costs by possibly reducing the amount of drying.

Development of engineering data used to design storage structures could result in cost saving by reducing material and construction costs.

As much as 20% by weight and 35% by volume could be saved in the storage structure by developing techniques of brown rice storage. Structures cost could be reduced by a substantial amount by development of new structural configurations.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	1

TITLE: Improving Techniques for Detection and Control of Stored Rice Insects. RPA 408-C

SITUATION: A substantial amount of stored and exported rice is either lost or damaged to the extent that reduction in value results due to stored grain insects. At present, there is a need for methods to determine the existence of insects in large bulk storage units in order to take protective measures before loss.

A concern in the use of insecticides for control is residual effects. There is a continuing need to develop insecticides and methods of application that leave little or no chemical residues, in order to protect rice as a human food.

OBJECTIVE: To develop optimum detection and control measures for insects attacking rice and rice products, and to develop effective insecticide application methods and fumigation techniques that will result in the lowest possible residues.

RESEARCH APPROACHES:

A. Studies to develop instruments and techniques for rapid objective measurement of internal "hidden" insect infestation of rice.

B. Studies on fumigation, protectants, environmental control, and other methods of inhibiting the spread of stored grain insects in rough and milled rice, with emphasis on methods leaving little or no chemical residue.

C. Research on biology and ecology of stored rice insects.

D. Coordinate research with RPA 408-B.

CHARACTER OF POTENTIAL BENEFITS: The reduction of losses in quantity and value of rice due to stored grain insects. Reduction in these losses would insure higher value to the producer, processor, and marketer. Elimination of residues would insure complete safety for the consumer.

Improve the image of the United States as an exporter through safe arrival at destination of clean, undamaged, insect-free rice, to assure a fair share in the foreign market.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
4	4

TITLE: Improved Methods and Techniques to Detect and Control Microbial Activity in Stored Rice. RPA 408-D.

SITUATION: During harvest, drying, and storage, rice may be handled in such a manner that bacteria, fungi, and their toxins develop which may result in loss in quality and may be hazardous to the consumer. There is a need for research to determine environmental conditions best suited to control, and possible elimination of the metabolites in stored rice.

OBJECTIVE: To determine the best methods of control or elimination of bacteria, fungi, and their toxins in rice.

RESEARCH APPROACHES:

A. Studies on the development of potentially harmful fungal metabolites in stored rice.

B. Studies of factors affecting the production and accumulation of known mycotoxins.

C. Studies to develop objective methods to detect and measure fungal activity as it affects the quality of rice.

D. Coordinate research efforts with RPA 406-D.

CHARACTER OF POTENTIAL BENEFITS: Reduction in quality and quantity loss prior to and during marketing. Reduction of danger to consumers of rice contaminated with potentially harmful fungal metabolites.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	2	2

TITLE: Determination of Physical Parameters of Rice. RPA 408-E

SITUATION: As processing, drying, storage, and handling of rice becomes more exact and sophisticated, a growing need arises to know precise properties of the grain. Such information is essential for accurate analysis, design, and operation of rice harvesting, handling, processing, and storage of rough, brown, and milled rice systems.

OBJECTIVE: To determine and evaluate physical parameters necessary to develop better processing and handling techniques and systems.

RESEARCH APPROACHES:

A. Determination of engineering properties as related to temperature and moisture content to include:
   1. Specific heat
   2. Thermal conductivity
   3. Thermal diffusivity
   4. Individual grain density
   5. Grain hardness
   6. Grain volume
   7. Grain surface area
   8. Hygroscopic equilibria
   9. Angle of repose
   10. Coefficient of friction
   11. Permeability
   12. Bulk density

B. Studies of the physics of the rice grain to relate stress, strain, fissuring, etc., to mechanical forces, moisture and/or temperature gradients as they may occur in the handling, drying, and other processes.

C. Studies to develop instruments and/or techniques for rapid measurement of quality parameters in rough and milled rice.

D. Coordinate research efforts with RPA 208, 307, 406, and 501.

CHARACTER OF POTENTIAL BENEFITS: More exact knowledge of the physical parameters of rice will enable the engineer and/or process scientist to design better and more efficient handling and processing components and systems for rice.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	0.5	1

TITLE: Identification and Evaluation of Quality Variables in Rice. RPA 501-A

SITUATION: Grades and standards in the marketing system should provide meaningful communication with respect to quality of a product in relation to its price and intended use. A system of grades and standards recognizing meaningful quality factors should be developed and established.

OBJECTIVE: To provide grades and standards that will effectively communicate value differences for varying gradations of quality.

RESEARCH APPROACHES:

A. Evaluate the effectiveness of existing grades and standards in serving the needs of sellers and buyers and for reflecting different gradations of quality which affect value and use.

B. Develop descriptive terminology for grades and standards which will characterize the different attributes of rice and rice products so as to facilitate communication between buyers and sellers.

C. Develop a uniform system of grades and standards recognizing those characteristics which reflect value and affect use.

D. Coordinate with research under 408-E, 501-B and 504-A and -B.

CHARACTER OF POTENTIAL BENEFITS: Improved communication through more precise terminology for describing varying gradations of quality. Prices would more accurately reflect value and a more competitive position in marketing rice in the world market would result.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	0.5	1

TITLE: Development of techniques and equipment for commercial measurement of quality variables in rice. RPA 501-B

SITUATION: Objective, quick and accurate measures for characteristics of economic significance (commercial) are needed along with increasing automation in the use of this information. The laboratory mill presently used to determine the milling yield of rice does not accurately correlate with actual milling outturns obtained by commercial processors. Most of the

United States rice mills are now using the Japanese made Salaki milling equipment. The greater milling efficiency of this new equipment may be contributing to the divergence of milling yield results between commercial and laboratory type mills. Sampling is largely accomplished at random by hand, with no assurance that the sample represents the total lot. Practically no mechanical appliances are used with little or no statistical consideration to insure representative sampling.

OBJECTIVE: To develop techniques and equipment for measurement of commercial value of rice.

RESEARCH APPROACHES:

A. Develop techniques and equipment for the rapid, objective measurement of quality in commercial and marketing channels.

B. Develop mechanical sampling devices.

C. Coordinate with research under 408-E, -F, and 501-A.

CHARACTER OF POTENTIAL BENEFITS: Development of instruments or machines and techniques for rapid, objective sampling and measurement of quality would lead to a reduction in the cost of inspection and grading. In addition, laboratory results would provide more accurate estimates of commercial results if better laboratory equipment were developed.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
0.5	1

TITLE: Optimal Drying and Handling Facilities for Rough Rice. RPA 504-A

SITUATION: The principal problem associated with drying rice with heated air is the susceptibility of rice to checking when dried rapidly, and its subsequent tendency to break when milled or handled. At the government's current price support level for long-grain rice, the value of head rice is over twice that for broken kernels. Therefore, current methods usually use intermittent drying over a long period of time to gain the maximum percentage of head rice. In some areas rice is dried at commercial dryers where the individual lot identity is maintained. All this tends to make rice drying costly. Research is needed to provide improved drying techniques that makes optimal use of heat and maintains a high quality product. Improved handling tehchniques and equipment design are needed to reduce rice breakage and labor required.

OBJECTIVE: To evaluate current technology and to develop more efficient work methods, techniques and criteria for improved equipment for drying, storing, handling, and preparation of rice for market.

RESEARCH APPROACHES:

A. Develop techniques and criteria for improved equipment to dry rice.

B. Develop criteria for modifying equipment to minimize physical damage to rice.

C. Develop improved techniques to store high moisture rice.

D. Develop improved handling methods to economically receive, ship and transfer rice at commercial dryers.

E. Coordinate with research under 406-A; 408-A and -B; and 501-A and -B.

CHARACTER OF POTENTIAL BENEFITS:

1. Increased value of the product produced by the rice industry.

2. Decreased cost of drying and handling.

3. Reduced physical loss in the product during storing and handling.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1.5	2.5

TITLE: Physical and Economic Efficiency in Marketing Rice. RPA 504-B

SITUATION: In 1962 there were approximately 65 rice mills and 400 commercial rice dryers in the United States. By 1968 the number had declined to about 45 active rice mills and 280 active commercial rice dryers. Further consolidation is expected over the next several years. Continual shifts in the relative importance of the several producing areas also are expected. Domestic markets are expected to increase about in proportion to the growth in population but foreign markets are likely to continue to be quite volatile. These changes will bring a growing need for economic analysis that will assist the rice industry in making optimum adjustments in marketing facilities and organization.

OBJECTIVE: To indicate adjustments required by producers, farmer organizations and drying, milling, and marketing firms to establish a marketing system of optimal efficiency.

RESEARCH APPROACHES:

A. Make comprehensive study of rice dryer and milling costs and develop construction and operating costs for well designed model plants of varying types and sizes.

B. Determine current and projected supply and demand patterns.

C. Make an economic evaluation of the rice grading system to determine changes needed at any level to reflect manufacturing and end product quality more adequately in prices.

D. Develop a systems model for the rice industry to determine optimal size, location, and distribution of facilities and marketing projected supplies.

E. Use the systems model as a tool to appraise the impact of adjustments in rice production on producers and agribusiness firms.

F. Coordinate with research under 408-A, -B, -E, and -F; 501-A and -B; and 504-C.

CHARACTER OF POTENTIAL BENEFITS: Reduce total cost of producing, handling, processing, and distributing the nation's rice crop. Thus, benefits would accrue to all segments of the industry and to consumers.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	3	3

TITLE: Pricing Efficiency in the Rice Industry. RPA 504-C

SITUATION: Much criticism is heard among the rice trade on the methods and procedures used in establishing the level of export subsidies for rice. Government price support activities and export subsidy payments influence the price of rough rice in the domestic market and for milled and brown rice in both the domestic and world markets. Yet in turn, export subsidy payments are calculated from the same world price which they influence.

OBJECTIVE: Analyze the pricing arrangement in international trade in rice, export price subsidies, quantity restrictions and to determine the impacts of these on the U.S. share of world markets and on the domestic pricing of rice.

RESEARCH APPROACHES:

A. Analyze the procedures and terms of exchange by which prices are established between exporter and foreign buyers.

B. Appraise the procedures by which the CCC prices and sells rice under various government programs and evaluate the methods by which foreign governments' purchasing missions procure grain in the U.S.

C. Analyze the effects of export subsidy payments on the pricing of rice in the world and domestic markets.

D. Appraise the effects of an international commodity agreement for rice on the quantity of exports and international pricing.

POTENTIAL BENEFITS: Increasing efficiency in pricing and marketing would improve the competitive position of U.S. rice in world markets. It is not possible to estimate potential benefits until exploratory investigations are carried out.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	0.5	0.5

Secondary Research Problem Areas

There are four Research Problem Areas in which research on rice should be conducted. These are listed in Table 2. Recommendations of the Joint Rice Task Force on the level of research on rice in these areas are given below.

TITLE: Adjusting Management Practices to Advances in Technology and Changes in Economic Factors. RPA 316

SITUATION: As research related to biological efficiency bears useful results rice producers are confronted continuously with choosing among improved varieties, new innovations in kinds and methods of application of agricultural chemicals, and related changes for rice as well as for secondary enterprises. In addition, annual choices among enterprises, and levels of inputs are prompted by actual or anticipated changes in prices received. Hence, there is a continuing need for information to guide farmers in making desirable adjustments in the kinds and amounts of inputs for specific enterprises, and in the amounts of resources they should commit to alternative uses. Rapid assimilation of research findings into the management practices of most rice farmers is basic to the problem of minimizing costs. In view of the large share of U.S. rice that is normally marketed abroad it is important that maximum efficiency in production operations is attained. The fact that other exporting countries likely will expand output during the years ahead gives added significance to this point. Such information is useful to managers of affiliated industries and administrators of agricultural programs.

OBJECTIVE: To maintain current data and make the necessary analyses that will enable farmers to make adjustments in resource use and management practices in accordance with changes in technology and in economic conditions.

RESEARCH APPROACHES:

A. Maintain continuous exchange of information among economists and physical scientists on new findings through research and their implications to producers.

B. Adopt or develop programming models for simulating rice - other crop rotation systems, and testing such programs, under varying conditions of costs and prices received to determine the cropping programs that will optimize total farm incomes.

C. Coordinate with farm adjustment research on other crops and livestock that are related to rice rotations.

POTENTIAL BENEFITS: Input costs of growing rice would be held at the minimum level. It is impractical to suggest a dollar value for these benefits.

RESEARCH EFFORT:	T F RECOMMENDATION	
	1972	1977
	2	2

TITLE: Useful Disposal of Waste Rice Hulls. RPA 407-A

SITUATION: Disposal of rice hulls is a major problem of long standing for the rice milling industry. Some are used in feeds, but most are burned in large piles for outright disposal or recovery of the porous, absorptive ash. Air pollution standards will soon preclude open burning and will require alteration of present methods of indoor burning. Fuel value, which is rather low, is not of primary concern for materials burned in home fireplaces, so that compressed logs resembling those made from sawdust offer good potential for using large quantities of rice hulls. Similarly, the suitability of charcoal briquettes for home barbecue use is not primarily dependent on high fuel value. The high ash content of rice hulls offers advantages by way of a stable heatholding base for home barbecue fires. The imminent necessity for disposing of hulls by methods other than uncontrolled burning alters the economies of hull disposal to justify development of products heretofore infeasible.

OBJECTIVE: To develop new uses for rice hulls such as converting to compressed logs for home fireplace use and for charcoal briquettes for home barbecue use to replace present air-polluting disposal of rice hulls by burning.

RESEARCH APPROACHES:

A. Develop methods for compressing ground or unground hulls with suitable binders, in presently available equipment, into fireplace logs capable of self-sustained ready combustion.

B. Develop methods for efficient carbonization of rice hulls to recover useful organic byproducts and a carbonaceous residue suitable for briquetting.

C. Develop methods to compress carbonized hulls, with or without binders, to yield briquettes satisfactory for home barbecue use.

D. Cooperate with industry in A, B, and C and in evaluating the commercial feasibility of processes and products developed in the research.

E. Coordinate with research under 406-A, 407-B and 504-A.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS: Present air and land pollutants from rice hull disposal will be removed by profitable disposal alternatives which will provide new industrial opportunities in rural areas and lower cost products for consumers.

The nearly 500,000 tons of rice hulls available for conversion to consumer products would yield a value of about $3.5 million if converted to 4-lb. logs

selling for 15¢ each and carrying a profit of 1.5¢ per log. Alternatively, if carbonized (40% yield) and converted to briquettes valued at 8¢/lb. with a profit of 0.8¢/lb., the increased value would approximate $3 million without allowance for any return from byproducts of the carbonization (destructive distillation).

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Feed Uses for Rice Milling Fractions and Straw. RPA 407-B

SITUATION: New air and land pollution regulations threaten to disrupt procedures traditionally used to dispose of residues left after growing and milling rice. The logical outlet for these residues is in animal feeds. Feeds provide the nutrients for the production, maintenance, and growth of animals but in certain feedstuffs the nutrients are not utilized biologically to their maximum extent. This is particularly true of high fiber feeds--- and rice bran, hulls, and straw fall in this category. As a result the available energy in these materials, is too low to allow their extensive use in poultry or ruminant rations.

Processing offers ways to increase the biological availability of nutrients in feeds. For example, recent research has shown that metabolizable energy (ME) can be increased significantly by processing -- 31% in the case of steam pelleted wheat bran, and up to 100% in steam pelleted alfalfa. Ammoniating rice hulls at high temperature produces a useful protein supplement for ruminants. High pressure steam treatment of alfalfa stems and wood pulp gives noticeable increased digestibility in artificial rumen trials. The present need is to find ways to treat rice byproducts to increase both their energy and digestibility so they can serve more widely in meeting the growing needs of our animal-based industries.

OBJECTIVE: To develop processing treatments for rice milling fractions and straw that will increase the utilization of their energy and other nutrients by ruminants or monogastric animals.

RESEARCH APPROACHES:

A. Investigate use of physical processes like grinding, milling, and pelleting to enhance the nutrient qualities of rice milling fractions and straw.

B. Investigate process treatments involving use of chemicals, enzymes, heat, and/or pressure to increase nutrient availability in these materials.

C. Investigate potential antinutritional factors in rice milling byproducts.

D. Coordinate this research with 406-A, 407-A and 504-A.

CHARACTER AND MAGNITUDE OF POTENTIAL BENEFITS:

A. Increased use of milling byproducts in local feed products would decrease animal production costs in rice growing and milling areas in the U.S.

B. Elimination of a waste disposal problem which currently contributes to the air and land pollution problem in rice growing and milling areas of the U.S.

Reasonable success in achieving the goal of this research would give a total benefit of over $8 million per year.

About 340,000 tons of rice bran and polish were produced last year. Parametric least cost linear programming data for poultry feeds indicate that with these high fiber feeds, each increase of 100 Kcal/lb. is worth 2¢/lb. Increasing the available energy from carbohydrate to reasonable levels through processing these feedstuffs would add 400 Kcal/lb. or $16/ton. Allowing $3/ton for processing costs, ($13/ton net savings) an industry-wide savings of $4.4 million could be anticipated.

Rice hulls have little market value now and may even have a negative value if disposal costs increase. Hulls can be valuable feedstuffs, if 90% of their carbohydrate can be made available to ruminants. This would amount to an increase of 1,200,000 Kcal/ton for rice hulls. Computer data indicate that each million calories of productive energy for cattle is worth $10.80. At 1967 levels this would make the total energy available from rice hulls worth over $9 million. If processing costs are $5/ton, a net saving of $4.0 million may be visualized from rice hulls.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	2

TITLE: An Evaluation of Consumers Purchasing Pattern for Milled Rice. RPA 506

SITUATION: It is apparent that striking changes are taking place in the preferences, buying habits, and decision making patterns of homemakers in different income levels, ethnic groups and consuming areas. An economic evaluation of such changes are essential in helping the rice industry to evaluate alternative government programs and to develop effective marketing strategies and promotional activities.

OBJECTIVE: To develop measures of price elasticities, income elasticities, and cross elasticities of demand for rice at the retail level, stratified by income ranges, ethnic groups and consuming areas.

RESEARCH APPROACHES:

A. Obtain data from a representative panel of homemakers regarding in significant details their purchases of rice and competing food products; the prices paid, type, kind and quantities bought, the store where purchased, the type of neighborhood where the store is located and similar matters of importance.

B. Develop measures of demand elasticities using approved statistical techniques for different income levels, minority groups and marketing areas.

POTENTIAL BENEFITS: Such information would contribute to improved communication and knowledge for modifying government programs, and developing marketing strategies and promotional activities. It is not practical to assign dollar values to the anticipated increase in quantities of rice moving through domestic markets.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
1	1

TITLE: Expansion of Foreign Markets for U.S. Rice. RPA 601

SITUATION: Foreign purchases comprise a major share of our total U.S. market, and rice contributes substantially to our favorable balance of trade. In 1967, two-thirds of total rice production moved into world trade channels either through dollar sales or government programs. As government programs are phased out, new commercial outlets are essential for a prosperous domestic rice industry. Demand is affected by the quality and selling price in foreign markets compared with exports from competing countries. The competitive position of U.S. rice in foreign markets would be strengthened if the institutional, legal and physical barrier to trade were identified, analyzed, and remedial measures taken.

OBJECTIVE: To increase the export of U.S. rice and to improve our competitive position in the world rice market.

RESEARCH APPROACHES:

A. Evaluate the influence of the following institutional characteristics on imports of U.S. rice: (1) role of the selected recipient governments in the importing of rice, (2) the role of the private importer, (3) the market structure-organization and competition among traders in the participating market, (4) methods and source of purchases, and (5) the method of grading and standard used.

B. Investigate transportation costs and methods to determine what types of transport and handling equipment will protect the rice and get it to foreign markets at the lowest cost.

C. Appraise marketing conditions in selected countries in regard to: (1) facilities for importing rice, (2) methods of handling, (3) channels of distribution and (4) wholesale and retail facilities.

D. Examine: (1) trends in marketing, (2) changing foreign or domestic habits and preferences of foreign consumers, (3) percapita consumption trends in relation to type and quality of rice, and (4) trends in quantity and quality of imports.

POTENTIAL BENEFITS: Gains to the U.S. rice industry would be reflected in increased exports, thus expanding the total market. With other market outlets holding constant any increase in the amount of rice would further improve our balance of trade.

RESEARCH EFFORT:

T F RECOMMENDATION	
1972	1977
2	4